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Research Summary

Audible Alert and TMA Lighting

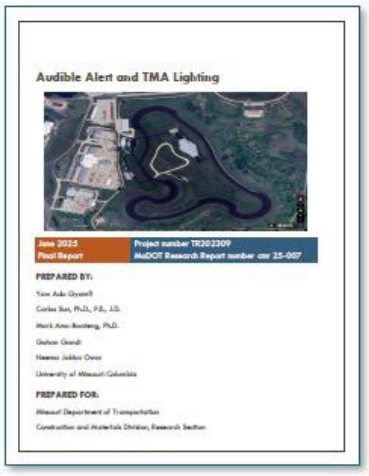
Work zone safety continues to pose a serious challenge, particularly for mobile work zone crews who are vulnerable to distracted or speeding drivers. While Truck-Mounted Attenuators (TMAs) are widely used to absorb crash impacts, rear-end collisions in work zones remain frequent and often result in severe injuries or fatalities. In Missouri alone, there are over 30 TMA-involved crashes annually, highlighting the urgent need for more proactive safety interventions.

To address this need, the AutoTMA Automated Audible Alert System was developed to provide real-time, proactive alerts that warn approaching drivers before a collision occurs. This system integrates AI-driven vehicle detection, predictive collision risk assessment, and adaptive audible alerts, offering a significant advancement over traditional passive safety measures like static signage or manual intervention.

Unlike conventional approaches, AutoTMA actively detects and categorizes oncoming vehicles based on speed, distance, and time-to-collision (TTC). When a vehicle is deemed to be approaching at an unsafe speed , the system dynamically triggers an audible warning to capture the driver's attention and prompt corrective action.

The Core system functions of the AutoTMA include:

- Real-Time Vehicle Detection & Tracking: Uses AI models, including YOLOv5.0 and DeepSORT v2.2, alongside LiDAR and radar sensors, to continuously monitor vehicles approaching the TMA (see Figure 1).
- Automated Collision Risk Assessment: Implements a TTC model to assess the threat level of each vehicle based on its speed and distance.
- Dynamic Audible Alert Activation: Deploys a multi-stage alarm system that scales in intensity depending on the severity of the threat, improving the chances of driver response.



"AutoTMA is an effective and scalable solution for reducing rear-end collisions in work zones."

AutoTMA was tested through a multi-phase process, including laboratory simulations, controlled field trials (see Figure 2), and full-scale work zone deployments. Key outcomes include:

- Detection Accuracy: Achieved over 98% accuracy in vehicle identification and tracking with minimal false positives.
- Fast Response Time: The full detection-to-alert process completes within 100–

150 milliseconds, allowing near-instantaneous warnings.

- Low Error Rates: The system demonstrated low false positive rates due to its multi-sensor fusion approach (vision, LiDAR, radar), and nearly zero missed detections in structured field tests

The AutoTMA was tested using three sensor configurations: camera-only, camera + LiDAR, and camera + radar. Camera-only systems are cost-effective but prone to false alerts in poor lighting or due to visual confusion from shadows. LiDAR offers high accuracy with depth sensing but is expensive, complex, and less effective in rain or fog. Radar provides reliable all-weather performance and rapid speed detection but has lower resolution hence difficult to recognize closely spaced vehicles.

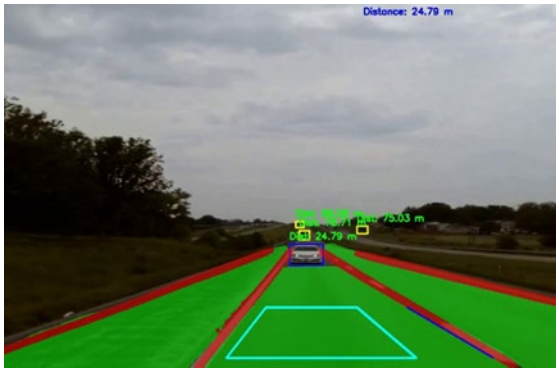


Figure 1: Realtime vehicle detection and tracking

Project Information

PROJECT NAME: TR202309—Audible Alert and TMA Lighting

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LEAD CONTRACTOR: University of Missouri-Columbia

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Project Manager

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